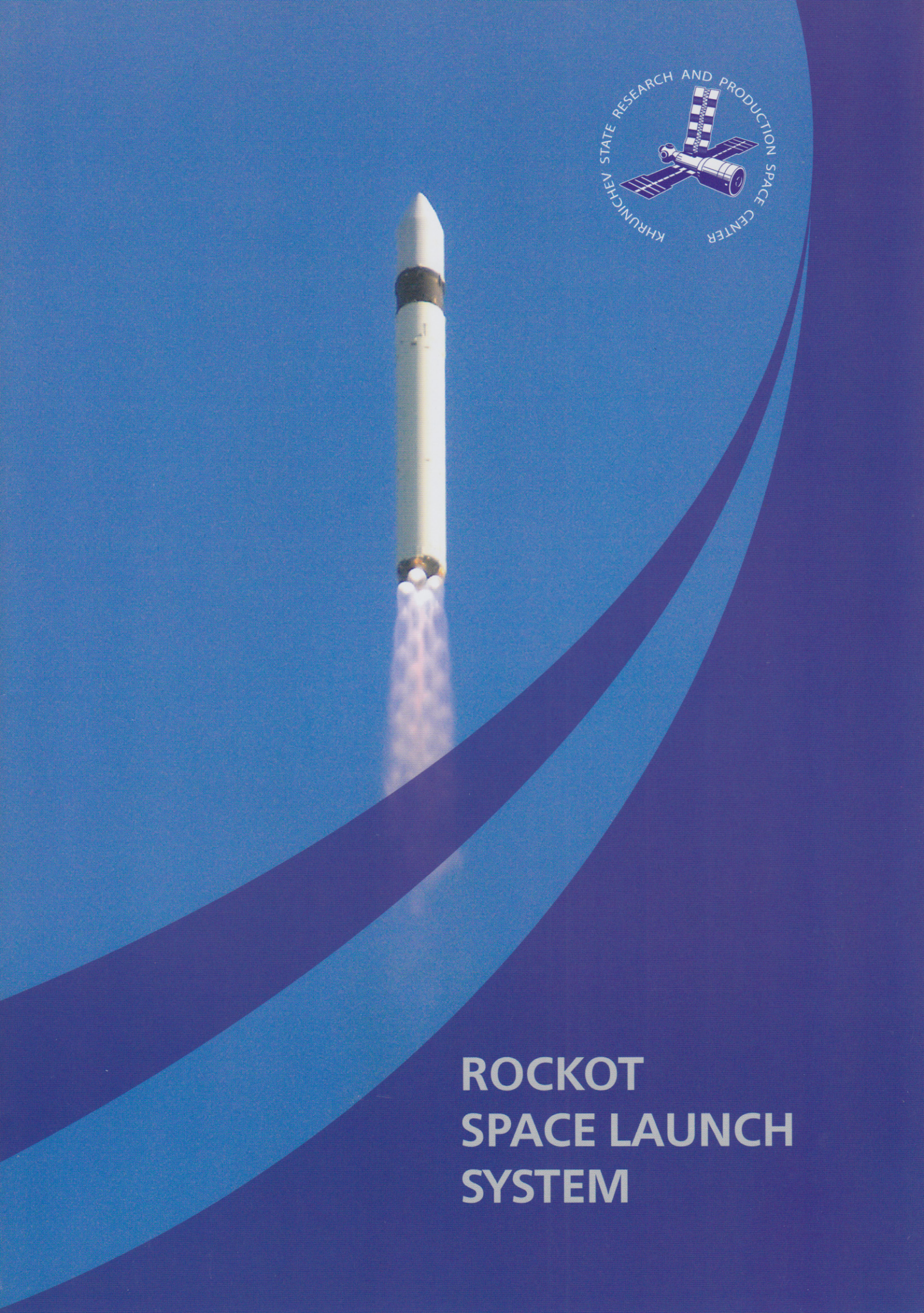


ROCKOT SPACE LAUNCH SYSTEM

EUROCKOT
Launch Service Provider

All Rockot commercial launches are conducted by Eurockot Launch Services – a Joint Venture with participation of EADS Astrium (51%) and KhSC (49%). Eurockot Joint Venture was registered in 1995; it is based in Bremen (Germany). The first Rockot commercial launch occurred in May 2000.

Rockot commercial missions launch from Plesetsk, a Russian launch site in the North.

EADS and Eurockot have invested over USD 40 million into the Plesetsk Launch Base infrastructure, advanced SC Processing Facility and Rockot Launch Pad Facility.

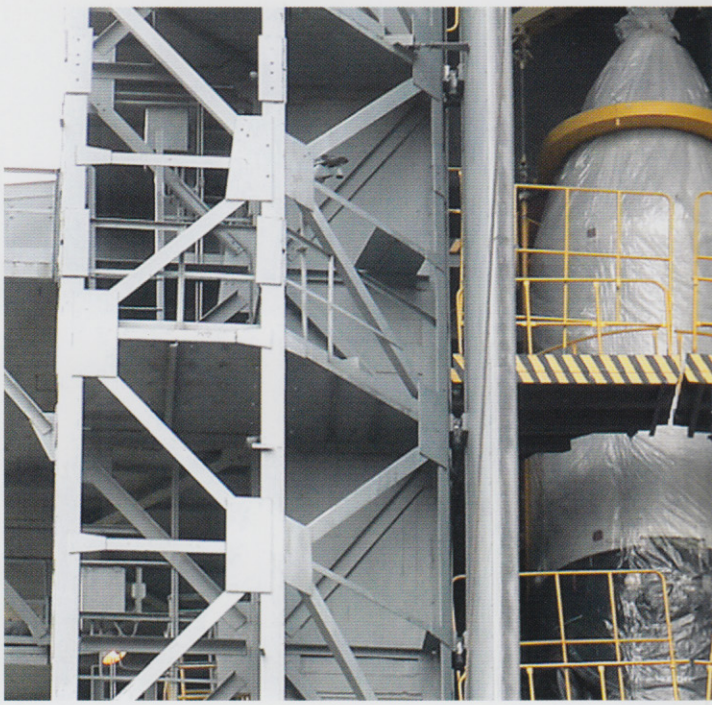
Eurockot provides Rockot launch services to the operators of commercial satellite systems, national space agencies and research organizations in the USA, Canada, Germany, France, South Korea, Japan and some other countries. Eurockot supports single payload launches as well as the insertion of two or more spacecraft into polar orbits in a single mission. These spacecraft are designed for Earth observation and remote sensing, communications and research purposes.

For over ten years Eurockot Launch Services GmbH has been providing commercial launch services to operators of small Earth observation, science and technology satellites into low Earth orbits. Earth observation missions comprise a substantial part of these launches.

Eurockot already performed successful launches for the European Space Agency in the past when the Earth Explorer series GOCE and SMOS climate research satellites as well as the PROBA-2 technology demonstrator were orbited in 2009 using Rockot launchers. These launches followed on from previous launches of Earth observation missions for customers in the US, Germany and Korea.

In February 2012 the Earth Observation Programme Directorate of the European Space Agency (ESA) and Eurockot Launch Services GmbH signed two new Satellite Launch Service Contracts in support of the European GMES (Global Monitoring for Environment and Security) programme. These contracts cover the launches of the Sentinel-2A and Sentinel-3A satellites. Individual launches of these two satellites are scheduled from late 2013 onwards, using Rockot launchers from Plesetsk Cosmodrome in Northern Russia. ESA selected Eurockot as the launch service provider for these missions following an international competition in 2010.

Eurockot's next launch will also be in support of the Earth Explorer programme as the three-satellite Swarm mission is planned to be launched in summer 2012. Eurockot currently has a backlog of four launches between 2012 and 2014 for ESA which, next to Swarm and Sentinel-2A and Sentinel-3A, also includes the so-called "Generic Mission", for which payloads still have to be defined by ESA.



Rockot/Breeze KM Launch Heritage

Rockot LV has been in use for the Eurockot commercial missions since 2000 while Russian spacecraft for various applications have been launching on Rockot since 2005.
Eurockot commercial missions:
10 launches (with single, dual and multiple payloads) from May 2000 through June 2010. Two satellite mockups and 18 spacecraft injected into orbit.
Federal missions:
5 launches from 2005 through the 1st quarter of 2011. 11 Russian spacecraft successfully put on orbit.

Past Commercial Missions using the Rockot Launch System

Launch Date	Payload	Customer/Operator	Mission Purpose
16th May 2000	SIMSAT 1/2	Khrunichev	Commissioning of launch facilities, qualification flight of commercial Rockot
17th March 2002	2 GRACE spacecraft	German Aerospace Center (DLR)/NASA	Gravity and Climate Experiment
20th June 2002	2 IRIDIUM spacecraft	IRIDIUM Satellite LC	Replenishment of IRIDIUM constellation
30th June 2003	MIMOSA MOST MIMOSA and MOST were launched together with NLS-1, NLS-2 and QuakeSat nano satellites MONITOR Mock up Simulator	Czech Astronomical Institute Canadian Space Agency Khrunichev Space Center	Earth Observation Astronomy Mass and Frequency Breeze Upper Stage
30th October 2003	SERVIS-1	USEF (Institute for Unmanned Space Experiment Free Flyer), Tokyo, Japan	Commercial-Off-The -Shelf (COTS) Parts Verification
8th October 2005 (Launch Failure)	CRYOSAT	European Space Agency	Earth Observation
28th July 2006	KOMPSAT-2	Korean Aerospace Research Institute (KARI), Republic of Korea	Earth Observation
17th March 2009	GOCE	European Space Agency	Earth Observation
2nd November 2009	SMOS and PROBA-2	European Space Agency	Earth Observation Technology Demonstration
2nd June 2010	SERVIS-2	USEF (Institute for Unmanned Space Experiment Free Flyer), Tokyo, Japan	Commercial-Off-The-Shelf (COTS) Parts Verification

Rockot, a lightweight launch vehicle, has been created based on RS 18 ballistic missile for Federal and commercial spacecraft launches. Rockot LV is designed to insert spacecraft with a mass of up to two metric tons into low Earth orbits. Rockot consists of three stages. The first two stages are essentially a booster unit from RS 18 (or, equivalently, SS 19) strategic missile and a new Breeze KM Upper Stage is employed as the third one.

Launch Base: Plesetsk. Type of Launch Pad Facility: ground, open. Located in the Russian North, Plesetsk Launch Base boasts various facilities conforming to the most stringent requirements of modern technology and enables Rockot LV to place in LEO up to 1950 kg of payload.

Rockot LV capabilities are most adequate for the insertion of smaller and medium-size spacecraft into sun synchronous and polar orbits as well as the orbits with significant inclination. Rockot can also be used to build satellite constellations by launching several spacecraft in a single mission. Besides, Rockot is capable of injecting lightweight payloads with auxiliary propulsion systems in the escape trajectories and for interplanetary missions.

High-efficiency liquid engines using nitrogen tetroxide (NTO, oxidizer) and unsymmetrical dimethylhydrazine (UDMH, fuel) are installed on the booster unit. These engines are designed by the Khimavtomatika Design Bureau, Voronezh.

KhSC put in a lot of effort trying to make Rockot accommodate the requirements imposed by the Government Environmental Appraisal. As a matter of fact, Rockot has become a "pathfinder" for the other launch systems in this area. According to the Russian Federation Environmental Appraisal Law Rockot was subject to mandatory environmental appraisal. KhSC experts completed a great amount of work selecting safe mission pathways with respective impact areas, generating the Rockot Environmental Datasheet and implementing other activities to make this launcher sufficiently safe for the environment.

Adapter System

Spacecraft launching on Breeze Upper Stage make use of various installation features called Adapter Systems (Adapters) and Dispensers. The primary structure of such a feature is bolted to the interface ring of the Upper Stage. On the other side, interfacing with the spacecraft, the Adapter System, or the Dispenser, is equipped with either a Separation System, essentially a clamp-band, or with point-to point attachments, like a system of mechanical locks activated by pyrotechnical devices. Dispensers are designed to carry a few payloads on a single primary structure. Hence, Rockot is capable of accommodating a broad variety of customer demands.

Breeze Upper Stage interface plane allows for the installation of different custom-made dispensers and adapter systems accounting for mission-specific features of the spacecraft to be launched. Depending on the quantity, shape and configuration, a mission may use a dispenser or an adapter system with either an aft end or a side spacecraft mounting. Similar to a Separation System, a Dispenser provides electrical interfaces for the connection of power and commanding/telemetry data lines running between the payload and its ground support equipment.

Rockot Performance

LV configuration	Two Stages plus Upper Stage Booster Stages 1 & 2: based on SS 19 (RS 18) ICBM boosters Stage 3: Breeze KM upper stage
Overall length with payload fairing	29.15 m
Propellant (all Stages)	NTO/UDMH
Lift-off mass	107,500 kg
Payload parking orbit mass (H circ = 200 km , i = 63 °)	1950 kg (Breeze KM) 2300 kg (Breeze KS)
Max. SC mass to orbit (H=400 km, i = 63 °)	1830 kg
Injection error :	
Orbit height	± 1 to 2 %
Inclination	± 0.03 to 0.05 %
Engine Type, Quantity, Thrust Values (sea level/vacuum):	
- Stage 1	15D95 liquid engine (3) + 15D96 (1), 188,000 kgf / 212,700 kgf
- Stage 2	Main Engine: 15D113 liquid engine (1), - / 23,980 kgf Steering Engine: 15D114 liquid engine, - / 1580 kgf
- Stage 3	Main Engine: S5.98 liquid engine (1), - / 2000 kgf Vernier: 11D458 liquid engines (4), 40 kgf Attitude control and stabilization: 17D58E liquid engines (12),1.3 kgf
PLF Diameter/ Length	2.5 x 2.62 / 6.74 m
Starting date of flight tests	May 2000 (3 successful missions of close prototypes performed in 1990–1994)

Payload Fairing

Payload Fairing structure consists of two halves with a split line. The halves have a honey-comb structure; they are made of carbon-fiber and aluminum alloy. Each half consists of a cylindrical section and two-cone section. Payload Fairing jettison is enabled with pyrotechnical devices. Initially the two halves separate along the split line and at the aft interface, then the two halves released by spring mechanisms rotate about the hinges installed at the base of the halves and jettison.

Breeze KM Upper Stage

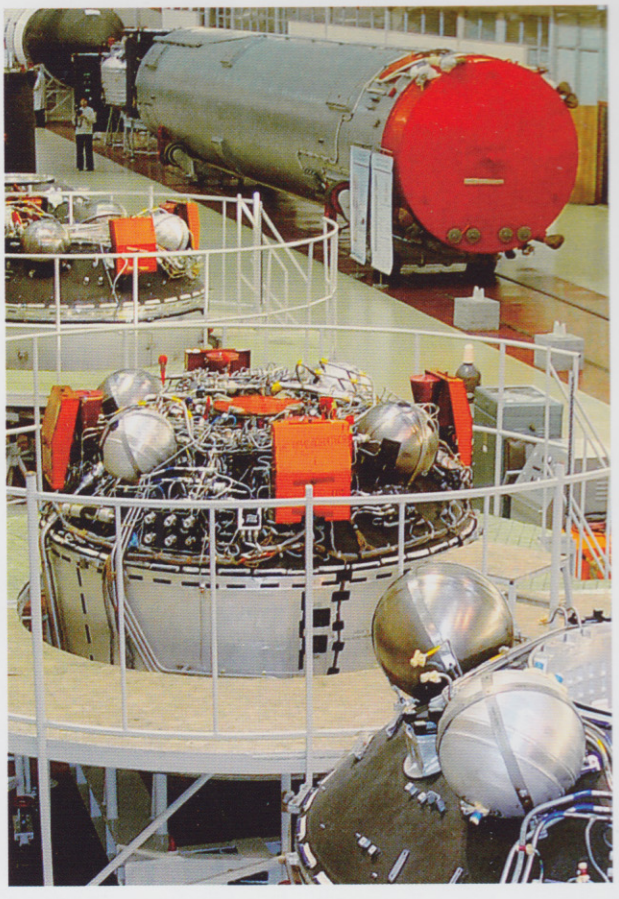
Rockot has a good performance largely due to the Breeze KM upper stage offering broad capabilities as far as injection of spacecraft into orbits at different altitudes and/or with a variety of inclinations. The Breeze KM equipment can control the spacecraft attitude to a high precision and supply spacecraft with enough power during both ascent and orbital flight lasting up to 7 hours. A special-purpose system provides for spacecraft and upper stage separation with the minimum possible disturbances.

Breeze KM includes a propulsion bay, a propellant bay, an equipment bay, a transition section ('a boat-tail') and an adapter. The propulsion bay accommodates a propulsion system, the propellant bay and a hydraulic system. NTO & UDMH, long-shelf-life propellants, are used for the propulsion system, which includes the main engine, a vernier thruster and an attitude control thruster. The main engine is well known for its high reliability. Designed by Isaev Khimmash Design Bureau and widely used in the space industry, this engine allows for multiple burns which enables implementation of various mission profiles including injection of payloads into one or several different orbits. Breeze KM has a high degree of commonality with the Breeze M upper stage.

The current Breeze KM configuration featuring the main engine with multiple burns capability provides for the implementation of various mission profiles.

Specifically, Breeze KM can support launching several payloads in a single mission with either successive or simultaneous separation of the payloads in orbits at different altitudes and with different inclinations. Breeze KM is capable of performing complex maneuvers, e.g. pre-programmed attitude rolls due to thermal control requirements, or SC separation at a pre-set altitude. Breeze KM is equipped with vernier thrusters allowing for fine adjustment of the final orbit thus providing an extremely high precision of injection.

The above features have been flight tested and utilized to their full capacity in the previous Rockot missions demonstrating highly precise orbital insertion.



Breeze KM Performance

Configuration	A single-piece structure with a conical tank compartment and the engine located in a recess in the fuel tank
Areas of application	Third stage of Rockot launch vehicle
Main specific features	Maneuverability in flight
Lift-off mass	6,475 kg
Max. propellant reserve (NTO + UDMH)	5,055 kg
Engine types/quantities/ vacuum thrust	S5.98 liquid propellant engine (main) /1 ea./ 2000 kgf 11D458 liquid propellant engines (vernier)/ 4 ea./ 40 kgf 17D58E attitude-control/stabilization thrusters/12 ea./1.3 kgf
Max. number of main engine burns	8
Max. autonomous flight duration	7 hrs
Starting date of flight tests	May 2000 (Three successful missions of close prototypes during 1990–1994)

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